09:47:04 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 09/06/91

Active

Project #: E-19-606 Cost share #: Rev #: 2
Center # : 10/24-6-R7106-1A0 Center shr #: OCA file #:
Work type : RES
Contract#: 1 R01 HL45485-01 Mod #: ADMIN 9/6/91 Document : GRANT
Prime #: Contract entity: GIT

Subprojects ? : N CFDA:
Main project #: PE #: N/A

Project unit: CHEM ENGR Unit code: 02.010.114
Project director(s):
YOGANATHAN A P CHEM ENGR (404)894-2849

Sponsor/division names: DHHS/PHS/NIH / NATL INSTITUTES OF HEALTH
Sponsor/division codes: 108 / 001

Award period: 910101 to 911231 (performance) 920331 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	138,074.00
Funded	0.00	138,074.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: QUANTITATION OF VALVULAR REGURGITATION: AN IN VITRO STUDY

PROJECT ADMINISTRATION DATA

OCA contact: Kathleen R. Ehlinger 894-4820

Sponsor technical contact

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NATIONAL INSTITUTES OF HEALTH
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Sponsor issuing office

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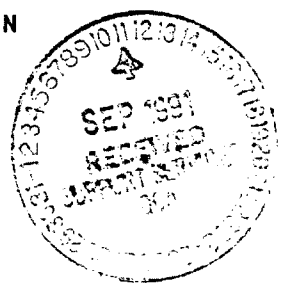
NHLB INSTITUTE
GRANTS OPERATION BRANCH
FEDERAL BUILDING
BETHESDA, MD. 20893

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NIH supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
ISSUED TO REVISE DELIVERABLE SCHEDULE.



GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 02/13/92

Project No. E-19-606_____ Center No. 10/24-6-R7106-1A0_

Project Director YOGANATHAN A P_____ School/Lab CHEM ENGR_____

Sponsor DHHS/PHS/NIH/NATL INSTITUTES OF HEALTH_____

Contract/Grant No. 1 R01 HL45485-01_____ Contract Entity GIT_

Prime Contract No. _____

Title QUANTITATION OF VALVULAR REGURGITATION: AN IN VITRO STUDY_____

Effective Completion Date 911231 (Performance) 920331 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	_____
Final Report of Inventions and/or Subcontracts	Y	_____
Government Property Inventory & Related Certificate	N	_____
Classified Material Certificate	N	_____
Release and Assignment	N	_____
Other _____	N	_____

CommentsYEAR 1 OF 4-YEAR PROJECT. *CONSULTING AGREEMENT W/DR. R. A. LEVINE.__

Subproject Under Main Project No. _____

Continues Project No. _____

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	N
Project File	Y
Other _____	N
_____	N

NOTE: Final Patent Questionnaire sent to PDPI.

SECTION IV PROGRESS REPORT SUMMARY	GRANT NUMBER HL 45485-02	
PRINCIPAL INVESTIGATOR OR PROGRAM DIRECTOR	PERIOD COVERED BY THIS REPORT	
A. P. Yoganathan	FROM	THROUGH
APPLICANT ORGANIZATION Georgia Institute of Technology	01/01/91	12/31/91

TITLE OF PROJECT *(Repeat title shown in item 1 on first page)*
Quantitation of Valvular Regurgitation: An In Vitro Study

(SEE INSTRUCTIONS)

1. PLANS FOR THE NEXT YEAR OF SUPPORT

No change to original plans.

2. STUDIES CONDUCTED DURING THE CURRENT BUDGET YEAR

A. FLOW MODELS: All of the flow models to be used in the first two years of the study have been built. Two separate pulse duplicator systems have also been constructed for the project.

B. COMPUTER SIMULATION STUDIES: To rigorously explore factors affecting jet size, a computer model was developed which simulates color Doppler jets for user inputs of lesion velocity, orifice velocity, orifice area, chamber depth, transducer depth and instrument settings. The software is easily used for a full range of physiologic conditions for all four cardiac valves. Animation of the output on a Silicon Graphics workstation enhances the user's ability to visualize changes in color Doppler images for different physiologic inputs. The results using this model in our laboratory have shown immediate clinical relevance about factors affecting jet size to an extent not possible, in vitro or in vivo.

C. INTERACTION OF SOLID BOUNDARIES WITH JETS: This study addressed the hypothesis that adjacent walls influence regurgitant jet size as seen on color Doppler flow maps. Steady flow was driven through circular orifices (0.02 to 0.05 cm^2) at physiologic velocities of 2 to 5 m/s. At a constant flow rate and orifice velocity, orifice position was varied to produce three jet geometries: free jets, jets adjacent to a horizontal chamber wall lying 1 cm below the orifice, and wall jets with the orifice at the level of the wall. Color Doppler flow imaging was performed at identical instrument settings for all jets.

In echocardiographic views perpendicular to walls (vertical views), most commonly used in vivo for imaging jets near cardiac structures, a jet lying along the wall appears smaller than a free jet produced by the same regurgitant flow. The wall jet can entrain fluid and expand only on one side, and it spreads laterally over the surface to a greater extent. The area of a deflected jet is increased by the Coanda effect, which draws the proximal jet towards the wall. Therefore, jet size cannot be related to the degree of regurgitation without considering jet geometry and adjacent walls.

D. EFFECTS OF INSTRUMENT SETTINGS AND TECHNICAL FACTORS: Color Doppler flow images and spectral Doppler tracings were obtained under steady flow conditions in the American Society of Echocardiography flow phantom. This flow phantom was designed in our laboratory. Measurements were taken at steady

flow rates over a range of 55 to 550 cm^3/s, using a variety of clinically available ultrasound instruments (ATL UM9, Toshiba 65A, 270A, Kontron Sigma 44, Vingmed SD100). Machine settings such as: packet size, wall filter, PRF, power function and scan line density were varied. The color images were analyzed on a MAC II ci system using software programs developed in our laboratory. The results indicate that for a given instrument, varying machine parameters has a marked effect on the visualized and the quantitative representation of the color flow image. Detailed statistical analyses of these data are currently in progress.

In addition we addressed the hypothesis that, at a constant peak flow rate, increasing heart rate could decrease the maximum apparent jet size by color flow Doppler mapping. We examined this in pulsatile flow, holding orifice size and peak flow rate constant and varying heart rate (70-180 beats/min) and frame rate (3 rates) for jets of low and high momentum (2-5 m/s). Maximum jet area was measured in 10 consecutive beats at each heart rate and frame rate, and averaged. Increased heart rate can cause underestimation (as much as 40%) of apparent jet size by color flow mapping for a give peak flow rate, particularly for jets with low momentum and delayed penetration into the receiving chamber. This may be relevant to acute severe regurgitation with increased heart rate. This effect can be reduced by increasing frame rate, and should be considered in relating jet size to the severity of regurgitation.

A Kontron Sigma-44 color flow Doppler unit with a two-frequency transmitter (QUASAR) can potentially increase the maximum detectable velocity. We imaged tube and jet flows in vitro, in order to evaluate the accuracy of the QUASAR system. Centerline velocities above the unshifted Nyquist limit were corrected to nonaliased displays. The QUASAR concept is a critical step toward obtaining quantitative color Doppler flow data for the first time. The importance of obtaining such physically meaningful data is highlighted by recently reported clinical assessment techniques which rely on a limitation of status-quo color flow Doppler, namely, aliasing.

E. MOST SIGNIFICANT ACHIEVEMENTS: During the past year we have developed a flow phantom that can be used for standardizing color Doppler flow mapping instruments in a scientific fashion. We are working closely with the clinical cardiology community through the American Society of Echocardiography to implement such standardization. The phantom was used to study different ultrasound instruments in our laboratory as part of the NIH project. The data collected demonstrated the technological and clinical problems faced by the cardiologist in making quantitative diagnoses of valvular regurgitation.

The studies of wall jets and heart rate effects clearly demonstrated the fact that even if instrument or technical factors were not a problem, physiologic and anatomic complications make quantitation of valvular regurgitation in the clinical arena a daunting task. The wall jet study showed how jet area measurement can lead to erroneous interpretation of the severity of valvular regurgitation due to fundamental fluid mechanic effects. The heart rate study also demonstrated that jet area measurements are less likely to be accurate when applied to a pediatric patient population.

Finally, our preliminary work with the Kontron Sigma 44 anti-aliasing

(QUASAR) algorithm, gives us hope that one of the major drawbacks of color Doppler flow mapping, namely aliasing at relatively low physiologic velocities, may be overcome in the near future. We are continuing fundamental fluid mechanic studies with this instrument in the arena of valvular regurgitation.

3. RESEARCH INVOLVING HUMAN SUBJECTS

N/A

4. RESEARCH INVOLVING ANIMALS

N/A

5. PUBLICATIONS

A. Manuscripts

1. E.G. Cape, A. P. Yoganathan, A. E. Weyman, R. A. Levine: Adjacent Solid Boundaries Alter the Size of Regurgitant Jets on Doppler Color Flow Maps. JACC, Vol. 17, pp. 1094-1102, 1991.

2. E. G. Cape, A. P. Yoganathan, R. A. Levine: Heart Rate/Frame Rate Interaction in Color Doppler Flow Mapping of Pulsatile Turbulent Jets: In Vitro Studies. Submitted to JACC.

3. S. P. Jain, P-H. Fan, E. F. Philpot, N. C. Nanda, A. P. Yoganathan: Influence of Various Instrument Settings on the Flow Information Derived from the Power Mode. Ultrasound in Med. and Biol. Vol. 17, pp. 49-54, 1991.

4. A. Parro, E. F. Philpot, N. C. Nanda, E. G. Cape, A. P. Yoganathan: Amplitude Information from Color Doppler: A Preliminary Study of the Power Mode. JACC, (In Press), 1991.

B. Abstracts and Conference Presentations

1. E. G. Cape, A. P. Yoganathan, R. A. Levine: Increased Heart Rate Can Cause Underestimation of Regurgitation Jet Size by Color Doppler Flow Mapping. JACC, Vol. 17, No. 2, 359A, 1991.

2. R. A. Levine, L. Rodriguez, E. G. Cape, C. Vesier, J. D. Thomas, A. E. Weyman, A. Cagniot, A. P. Yoganathan: The Proximal Flow Convergence Method for Calculating Orifice Flow Rate Requires Correction for Surrounding Leaflet Geometry. JACC, Vol. 17, No. 2, 359A, 1991.

3. E. G. Cape, T. D. Cooper, N. C. Nanda, R. A. Levine, A. P. Yoganathan: Quantitative Velocity Measurement by Color Flow Doppler: Potential of an "Anti-Aliasing" Algorithm. JACC, Vol. 17, No. 2, 201A, 1991.

4. J. D. Thomas, E. G. Cape, D. H. Thoreau, R. A. Levine, A. P. Yoganathan, A. E. Weyman: Automated Jet Momentum Calculation from Digital Doppler Flow Maps. JACC, Vol. 17, No. 2, 149A, 1991.

5. E. G. Cape, J. C. Mendoza, A. P. Yoganathan: "Quantitative" Color Doppler Flow Mapping of Cardiac Blood Flow (Invited Lecture). ASME Biomechanics Symposium Proceedings, AMD, Vol. 120, pp. 13-16, 1991.

6. E. G. Cape, A. Cagniot, J. K. Jones, E. Muralidharan, R. A. Levine, A. P. Yoganathan: Quantitation of Intracardiac Jet Flows: Computer Visualization and In Vitro Studies. Proceedings of the 16th World Congress of Biomedical Engineering, pp. 553, Kyoto, Japan, July 1991.

7. A. Cagniot, E. G. Cape, R. A. Levine, A. P. Yoganathan: Quantitation of Mitral Regurgitation: An In Vitro Study. Proceedings of the 10th Southern Biomedical Engineering Conference, Atlanta, GA, October 1991.